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EXAMINING THE CHARACTERISTICS OF FATAL PEDESTRIAN CRASHES

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| 16. Abstract Pedestrian safety has become a strategic priority for UDOT over the past two years. In Utah, pedestrians make up over 12% of total roadway fatalities while less than 2% of all trips are taken on foot. This over-representation of risk led to the creation of the Utah Pedestrian Safety Action Plan in 2015. Several of the goals in that plan speak directly to improving methods for collecting data regarding pedestrian crashes. One major drawback in current reporting is that there is little consistency across or even within jurisdictions in what is included about a pedestrian on a crash report. The level of detail for a motorist involved in a crash is relatively standard, however it is up to the responding officer to decide what is included on the crash form about the pedestrian. By conducting a detailed evaluation of crash reports for 119 fatal pedestrian crashes (2012-2014) and analyzing additional data for all pedestrian crashes (2006-2015) this research seeks to improve UDOT's understanding of pedestrian crashes resulting in a fatality. Findings include that a large majority of crash reports include at least one and often more coding errors. Up to 15% of reports from fatal pedestrian crashes have absolutely no narrative of what occurred. Additional analysis identified a profile for a typical fatal pedestrian crash. Fatal crashes are most likely to occur in the early spring or late fall in lower light conditions when visibility is already limited. Potentially in bad weather when a wide road is wet or icy. These crashes involve a pedestrian who may be impaired, participating in illegal and unpredictable behaviors such as improper crossing or wearing clothing that is not visible. Drivers are most likely to be impaired or distracted, and speeding straight ahead. Recommendations include conducting a thorough evaluation of current crash report procedures and forms; conducting trainings for law enforcement on how to accurately report on pedestrian crashes; and continue existing education programs on pedestrian safety. | | | | | |
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LIST OF ACRONYMS

| | |
|-------|--|
| ANOVA | Analysis of Variance |
| FARS | Fatality Analysis Reporting System |
| FHWA | Federal Highway Administration |
| NCHRP | National Cooperative Highway Research Program |
| NHTSA | National Highway Traffic Safety Administration |
| PBIC | Pedestrian and Bicycle Information Center |
| UDOT | Utah Department of Transportation |
| UDPS | Utah Department of Public Safety |
| USDOT | United States Department of Transportation |

EXECUTIVE SUMMARY

In Utah, pedestrians make up over 12% of total roadway fatalities while less than 2% of all trips are taken on foot (Zero Fatalities, 2016). This research seeks to improve UDOTs understanding of pedestrian crashes resulting in a fatality by examining each incident in further detail, and identifying: 1) What limitations are exhibited in current pedestrian crash reporting?; 2) Do pedestrian fatalities exhibit common crash characteristics; 3) What role does pedestrian fault play in fatal pedestrian crashes?; 4) Are pedestrian fatalities more common on certain days or at certain times?; and 5) Are there significant differences between fatal and non-fatal crashes?

Two major databases are being used for this research. The first includes all pedestrian fatalities involving at least one vehicle that occurred from 2012-2014 (119 cases) as identified from the Fatality Analysis Reporting System (FARS) database. The second database includes crash report data for all crashes involving at least one vehicle and pedestrian from 2006-2015 (17,353 cases and 7,093 crashes). Supplemental data gathered from report narratives, UDOT Safety Coordinator notes, and news reports was reviewed and added to the first fatality database.

The analysis found that a large majority of reports from fatal pedestrian crashes are inaccurate, most commonly containing coding errors and a lack of detail/officer narrative. Only 33% of the reports analyzed contained no errors. 15% of the crash reports involving a pedestrian fatality contained three or more coding errors.

When examining characteristics of fatal pedestrian crashes, the analysis found that over 10% of fatal pedestrian crashes occurred during inclement weather with wet or icy roads. The weather differed significantly during fatal vs non-fatal pedestrian crashes.

Vehicle maneuvering at the time of the crash significantly differed between fatal and non-fatal pedestrian crashes as well. In 78% of fatal crashes the vehicle was traveling straight. This was significantly more common than when a vehicle was turning (left turns - 6.3%; right turns - 2.5%). Speed also played a significant role. Vehicles involved in fatal pedestrian crashes were found to be traveling significantly faster than vehicles involved in non-fatal crashes.

Drivers contributed to the cause of the fatal crash in a majority of cases and were most likely to be distracted (20%), driving while intoxicated (9.5%) or speeding (5%). Pedestrians often contributed to fatal crashes as well. The most common pedestrian actions included improper crossing of the roadway (21.5%), being improperly in the roadway (10%), and lack of visibility (8%). Both pedestrian and driver behaviors differed significantly between fatal and non-fatal pedestrian crashes.

The age of the pedestrian significantly differs in fatal vs non-fatal pedestrian crashes. Pedestrians killed in a crash are on average 14 years older than those who survive a crash. The older a pedestrian is, the more likely the crash is to be fatal. The odds of a fatal crash occurring in daylight, or while a vehicle is turning right are significantly lower than in other conditions. Crashes occurring in bad weather (sleet/hail), on roadways with more lanes, or when the driver is speeding are also significantly more likely to be fatal. Lastly, crash timing is significantly correlated to fatality risk. The odds of a fatal crash occurring on Saturday and Sunday are significantly higher than one occurring mid-week. The odds of a fatal crash occurring in March, July, October, and December are higher than in September.

Analysis can only be as accurate as the data on which it is based. If the coding of the crash data is inaccurate then any subsequent analysis will also be flawed. This will result in programming and decision making based on inaccurate invalid data. This report concludes by recommending a thorough evaluation and consideration of the current components of the crash report, particularly those categories relevant to crashes involving pedestrians. Likewise, it is recommended that additional training be provided for law enforcement agencies regarding how to accurately and appropriately complete a crash report form for an incident involving a pedestrian. This will ensure increased accuracy and higher quality data moving forward.

Lastly, Utah currently has a large number of existing programs in place addressing pedestrian safety. These existing programs already cover a majority of the characteristics identified as being correlated to fatal crash risk. It is recommended that an evaluation of existing program effectiveness be conducted annually to identify which programs are seeing results, and which may need to be amended to create more positive outcomes.

1.0 INTRODUCTION

1.1 Problem Statement

Pedestrian safety has become a strategic priority for UDOT over the past several years. In Utah, pedestrians make up over 12% of total roadway fatalities while less than 2% of all trips are taken on foot (Zero Fatalities, 2016). This over-representation of risk led to the creation of the Utah Pedestrian Safety Action Plan in 2015. Several of the goals in that plan speak directly to improving methods for collecting data regarding pedestrian crashes. One major drawback in current reporting is that there is little consistency across or even within jurisdictions in what is included about a pedestrian on a crash report. The level of detail for a motorist involved in a crash is relatively standard, however it is up to the responding officer to decide what is included on the crash report about the pedestrian. In the first two months of 2015 there were 8 pedestrian fatalities in Utah. Seven of those fatalities included pedestrian error (e.g. crossing against a signal, crossing mid-block, etc.). The circumstances surrounding these fatalities were acquired from media reports and not the crash report at the scene, as this distinction was not readily available from the crash forms. Between 2006 and 2014 the two most significant lines on the crash report form for a pedestrian crash were left blank over half of the time. “Pedestrian contribution to crash” was left blank 56% of the time and “Driver contribution to crash” was blank on over 65% of forms. Without accurate data, it is very difficult to determine what is causing pedestrian crashes that end in a fatality. This makes it nearly impossible to address and mitigate for these issues to make roadways safer for pedestrians.

1.2 Objectives

This research seeks to improve UDOTs understanding of pedestrian crashes resulting in a fatality by examining each incident in further detail. Using crash report narratives (rather than the standard report form) as well as witness statements and other notes from the scene, combined with information from any news reports made at the time, will provide a better understanding of the circumstances that result in a pedestrian fatality by identifying the following:

- What limitations are exhibited in current pedestrian crash reporting?

- Do pedestrian fatalities exhibit common crash characteristics?
- What role does pedestrian fault play in fatal pedestrian crashes?
- Are pedestrian fatalities more common on certain days or at certain times?
- Are there significant differences between fatal and non-fatal crashes?

The recommendations from this work will allow UDOT to promote non-motorized safety by addressing specific factors that contribute to fatal crashes as well as provide improved training to law enforcement on ways to capture more comprehensive information at pedestrian crash scenes.

1.3 Scope

This research utilizes two main databases. The first includes all pedestrian fatalities (involving at least one automobile) occurring between 2012 and 2014 across Utah. For each crash comprehensive information was collected, including the crash report, witness statements, other notes from the scene, and any news reports made at the time. Using this information an exhaustive list of contributing factors for each incident is identified, including identifying major pedestrian, driver, and environmental contributions. The second database included existing crash report data for all crashes involving a pedestrian 2006-2015. No additional data collection or manipulation was performed on this database.

1.4 Outline of Report

The report is organized according into 6 Sections, as follows: Section 2 provides a brief literature review examining pedestrian travel behavior and safety, as well as a summary of the current state of knowledge regarding fatal pedestrian crashes. Section 2 also includes the research methods employed in this work, including a description of the study methods and justifications. Section 3 presents the data collected for this study and provides summary characteristics for the crash reports. Section 4 presents both qualitative and quantitative analysis of the fatal pedestrian crashes, including a comparative analysis of the different data sources.

Section 5 provides conclusions based upon the data provided in the previous sections and Chapter 6 outlines the author's recommendations for implementation.

2.0 LITERATURE REVIEW

2.1 Overview

A thorough literature review was performed on pedestrian safety and characteristics that have been shown to contribute to fatal pedestrian crashes. This chapter provides background information on pedestrian crash statistics both in Utah and nationally, and provides an overview of pedestrian travel behavior. This section also includes a discussion of the research methods employed and the justification for each.

2.2 Background and Literature Review

A pedestrian is defined, under Utah State code, as “anyone traveling on foot or in a wheelchair” (Utah Code, 2016). While some could argue that the definition is limited, the rights and responsibilities provided to pedestrians in Utah are specific. Pedestrians are expected to comply with the rules of the road and to follow all regulatory signs and signals. However, “when traffic-control signals are not in place or not in operation, the operator of a vehicle shall yield the right-of-way by slowing down or stopping if necessary” (Utah Code, 2016). Utah Code part 41-6a-1002 also states that “a pedestrian may not suddenly leave a curb or other place of safety and walk or run into the path of a vehicle which is so close as to constitute an immediate hazard” (2016). While vehicle drivers are required to “exercise care to avoid colliding with a pedestrian”, collisions still occur between pedestrians and motor vehicles, and the contributing factors are not always easily identifiable.

2.2.1 Pedestrian Crash Statistics

Over 80% of people in the U.S. report walking at least once per week, and 92% report feeling safe while walking. In fact, less than 3% of people report having been injured while walking in the past two years (Schroeder and Wilbur, 2013). However in 2014, 4,884 pedestrians were killed in traffic crashes nationwide; a 2-percent increase from 2013 (NHTSA, 2016). On average, a pedestrian was killed every 2 hours, and injured every 8 minutes. NHTSA data (2016) has shown that since 2011 there has been a steady increase in the number of

pedestrian fatalities nationwide (up 4% from 2011-2015), and 90 percent of the pedestrians were killed in traffic crashes that involved single vehicles.

According to the Utah Department of Public Safety (UDPS), in 2014 37 pedestrians were killed in motor vehicle crashes on Utah roads. While pedestrians account for only 1% of persons involved in crashes, they account for 14% of deaths (UDPS, 2014). Pedestrian crashes are 11.3 times more likely to result in a death than other motor vehicle crashes (State of Utah, 2014).

Demographics

Nationally, the average age of pedestrians killed in traffic crashes is 47. Over 20% percent of all pedestrians killed and an estimated 11 percent of all pedestrians injured are age 65 and older (NHTSA, 2014). In Utah, however, one-half (49%) of the pedestrians involved in crashes are under 25 years of age (UDPS, 2014). Overall, the largest percentages of pedestrians in crashes are aged 10-24 years (38.7%) and the highest percentage of pedestrian deaths occur in the 40-49 year age group (29.7%). The average age of a pedestrian killed in a crash is 39 (State of Utah, 2014). Utah's population is significantly younger than the national average (Median age: Utah=29.2, U.S.=37.2), which likely accounts for this difference (U.S. Census, 2010).

More than two-thirds of the pedestrians killed (nationally) in traffic crashes are males, which is more than double the rate for females (NHTSA, 2014). Likewise, the majority of all pedestrians hit (57.6%) and pedestrians killed (60.0%) in Utah crashes are male (State of Utah, 2014).

Geographic Location

Studies of pedestrian fatalities at the local level have found that the number of pedestrian crashes (per population) is four times higher in large urban areas, and twice as high in small or midsize urban areas when compared to rural areas. Research has shown that while large cities experience the majority of pedestrian deaths, they are also home to the lowest income neighborhoods which experience a disproportionate number of fatalities (USDOT, 2015). This trend holds true in Utah. In 2014, urban areas had a much higher total pedestrian-motor vehicle crash rate per 10,000 population (3.69) than rural areas (2.16). Salt Lake County alone accounted for 50% of the pedestrians involved in crashes and 43% of the pedestrian fatalities

(State of Utah, 2014). However, pedestrian crashes in rural areas are more likely to result in a fatality (0.16 per 10,000) when compared to crashes occurring in urban areas (0.12 per 10,000) (State of Utah, 2014).

2.2.2 Pedestrian Travel Behavior

The study of travel behavior examines the decision making processes employed when people make transportation choices including things as general as travel mode and route, or as specific as when to change lanes or whether or not to signal before turning. A number of factors can influence an individual's travel behavior. Demographics such as gender, age, income, household size, home and auto ownership, occupation, etc. have all been shown to impact travel decisions (Burbidge, 2009).

Traditionally, researchers have identified the very young (ages 16 and under) and seniors (ages 65+) as those most likely to participate in walking as a mode of transportation (Burbidge and Yoon, 2010). However this trend has begun to change. Young adults in the "Millennial" generation are driving less, waiting longer to get driver's licenses, and are more frequently dependent upon public transportation. The U.S. Department of Transportation (USDOT) has found that "the number of miles driven alongside car ownership and licensing rates among young people are at their lowest figures in decades" (USDOT, 2015). When coupled with the newfound popularity of rideshare apps such as Uber and Lyft, this large segment of the population is enhancing their mobility without being tied to a personal automobile. As more transportation options become available, travel behavior and trends will inevitably change. Many cities in Utah and across the country are promoting multimodal facilities to accommodate these changes, which concomitantly encourage people to walk more. In turn, communities are becoming increasingly aware of the need to improve safety for pedestrians (USDOT, 2015).

While the number of traffic fatalities has been on the decline in recent decades, there has not been an equivalent decline in pedestrian fatalities. Some have argued that growing pedestrian fatality and injury counts may simply reflect population growth or people making more trips by walking and bicycling therefore increasing their exposure to traffic (Pucher, et al, 2011). According to the Pedestrian and Bicycle Information Center (PBIC, 2016) there is no

reliable source of exposure data for pedestrians because of the difficulty in accurately estimating the number of miles people walk each year, or how much time people spend walking or crossing the street. This makes it difficult to calculate exposure and risk for pedestrians.

Pedestrian behaviors can contribute to the likelihood of being involved in a crash with a motor vehicle, as well as the crash severity. Crossing the street outside of a marked crosswalk at an intersection increases the risk of a crash. Data shows that 70 percent of pedestrian fatalities occur at non-intersection locations (USDOT, 2015). Alcohol, drug use, or other impairment, as well as inattention and distraction can cause a driver or pedestrian to lose control of their vehicle or significantly increase their reaction time and ability to make decisions quickly (Brookshire, 2016).

Distracted driving has become a major focus in recent years due to its contribution to crashes. The most notable distraction in the current era is likely the use of an electronic device while operating a motor vehicle. Many have argued that pedestrians can be equally distracted while walking by texting, dialing, reading, etc., which can reduce their situational awareness and increase their risk of being hit by a motor vehicle (Thompson, et al, 2013). However, a comprehensive review sponsored by the National Highway Traffic Safety Administration (NHTSA) examined the potential impact of pedestrians who are distracted by electronic devices, including cell phones, tablets, personal music devices, etc. and found no significant scientific evidence to quantitatively measure the extent to which pedestrian safety is affected as a result of distraction among drivers and pedestrians (Scopatz and Zhou, 2016).

Impairment caused by alcohol or drug use is a major contributing factor to vehicle crashes. 31% of traffic related deaths can be attributed to alcohol impaired driving crashes (NHTSA, 2015). In recent years the data has revealed that walking while intoxicated can be just as dangerous if not more. In 2014 alcohol was present in the bodies of nearly 40% of pedestrians killed in motor vehicle crashes (compared to 17% of drivers). Nearly one-third of pedestrians killed had a blood alcohol level above the legal driving limit (.08 grams per deciliter (g/dL) or higher) (NHTSA, 2016). As a result of anti-drunk driving campaigns, many individuals are choosing to walk home after drinking. However, when pedestrians are under the influence of

alcohol, they may make bad decisions such as trying to cross a road in the wrong place, crossing it against the light, or trying to beat a car that is coming toward them.

While distraction and impairment may be the most easily identifiable causes of pedestrian/motor vehicle crashes, a comprehensive review by the National Cooperative Highway Research Program (NCHRP) identified five key factors that contribute to a higher risk of a pedestrian being involved in a collision resulting in severe injuries or death (NHTSA, 2004). They include:

- **Excessive motor vehicle speed-** Vehicles driving faster than the posted speed limit or too fast for existing roadway conditions increase their risk of hitting a pedestrian. As vehicle speed increases the likelihood of a pedestrian fatality increases. For example, 75% of pedestrians will survive being hit by a car traveling at 25 miles per hour, but only 10% of pedestrians will survive being hit by a vehicle traveling 50 miles per hour (Tefft, 2012).
- **Conflicts at crossing locations-**When a crossing location does not adequately accommodate pedestrians they are more likely to be hit. For example, a mobility impaired pedestrian may not physically be able to cross a wide street in the allotted amount of signal time. In 31% of pedestrian involved crashes, drivers were turning, and in nearly half of all crashes (43%) the pedestrian was in a marked crosswalk (UDPS, 2014).
- **Inadequate conspicuity-**When pedestrians are not visible due to time of day (light or dark, sun reflectivity) or dark clothing choices, it is difficult for drivers to see them and stop in time to avoid a collision. Nationwide in 2014, 72% of pedestrians killed were struck in dark conditions (NHTSA, 2016).
- **Poor compliance with traffic laws and proper use of facilities-**Drivers and pedestrians who do not comply with traffic laws put themselves and others at risk. Failing to yield to pedestrians at crosswalks, walking on the wrong side of the road or in the shoulder rather than on the sidewalk, crossing against a traffic signal, etc. can all lead to serious

injury/death. Often poor compliance is the result of misunderstanding traffic control devices, or inadequate/poorly designed facilities.

- **Inadequate separation**-When pedestrians do not have a dedicated travel space that is sufficiently separated from higher speed vehicular traffic, they may not be seen by drivers. When adequate infrastructure is not available pedestrians can be forced to walk in the shoulder or on the roadway which can result in a collision.

Pedestrian and driver travel behavior play a critical role in determining if and when a fatal crash occurs. However, there is limited data available to the Department of Transportation and other agencies relating to traveler decision making and behavior leading up to a crash. Particularly regarding pedestrians. This research fills a critical gap in existing knowledge by examining not only the physical characteristics of fatal pedestrian crashes (speed, time, location, etc.) but also thoroughly examining the travel behavior of the driver and the pedestrian leading up to the crash. This will be accomplished by examining the contribution of pedestrian fault for the first time on a case-by-case basis.

2.3 Study Methods

This research will employ a number of statistical analysis methods to describe trends in the data as well as make predictions regarding correlation and causality between variables. Each method has been selected based on its appropriateness for use with this dataset relative to the research questions and hypotheses. These methods will include using summary statistics, independent sample t-tests and binary logistic regression models. Each of these methods is described in detail below.

2.3.1 Summary Statistics

Summary statistics are used to provide a quick and simple description of the data without any predictive component or significance testing. Summary statistics can include mean (average), median (center point of data), mode (most frequently occurring value), minimum value, maximum value, value range, standard deviation, frequency percentages, etc. Summary statistics will be used in this analysis to provide context for the fatal crash data. Specifically, this type of

analysis will be used to describe the limitations of the crash reports and provide an overview summary of the common characteristics in fatalities, pedestrian fault and the day/time analysis.

2.3.2 Pearson's Chi-Square Test

A Chi-Square test is a statistics test used on categorical data to compare an observed distribution to a theoretical one (measuring goodness of fit) in one or more categories. The events included must be mutually exclusive (e.g. weather cannot be clear and raining at the same time), and have a total probability of 1 (Greene, 2015).

Model:

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

where

χ^2 is the chi-square value

Σ is the summation sign

O is the observed frequency

E is the expected frequency

The Chi-Square test will be used to determine the goodness of model fit for analysis using any categorical data. This will include variables such as weather conditions, vehicle maneuvers, roadway conditions, pedestrian action, lighting, etc.

2.3.3 Independent Samples T-Test

An Independent Samples t-Test compares the means of two independent groups (fatal crashes vs non-fatal crashes) in order to determine whether there is statistical evidence that the associated population means are significantly different. The Independent Samples t-Test is a parametric test. The Independent Samples t-Test can compare the means for two and only two groups. It cannot make comparisons among more than two groups (which would require an Analysis of Variance – ANOVA).

Model:

When the two independent samples are assumed to be drawn from populations with identical population variances (i.e., $\sigma_1^2 = \sigma_2^2$), the test statistic t is computed as:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\left[\frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2} \right] \left[\sqrt{\frac{1}{n_1} + \frac{1}{n_2}} \right]}}$$

where

\bar{x}_1 = Mean of first sample

\bar{x}_2 = Mean of second sample

n_1 = Number of observations in the first sample

n_2 = Number of observations in the second sample

s_1^2 = Variance of first sample

s_2^2 = Variance of second sample

s_p = Pooled standard deviation

The calculated t value is then compared to the critical t value from the t distribution table with degrees of freedom $df = n_1 + n_2 - 2$ and chosen confidence level. If the calculated t value is greater than the critical t value (≈ 1.7 - 2.0 depending on the sample size), then we reject the null hypothesis (Greene, 2015).

Assumptions:

- Dependent variable must be continuous (e.g., interval or ratio level)
- Independent variable is categorical
- Cases have values on both the dependent and independent variables
- Independent samples/groups
- There is no relationship between the subjects in each sample
- No influence between groups or subjects
- Random sample of data from the population
- Normal distribution (approximately) of the dependent variable for each group

- Homogeneity of variance across groups
- Few outliers

The Independent Samples t-Test will be used to compare the fatal crashes to non-fatal crashes for a number of study variables. The goal of this analysis is to identify significant differences between the two groups. A subsequent analysis will identify how specific variables impact fatalities by using a more complex binary logistic regression technique described below.

2.3.4 Binary Logistic Regression

Binary logistic regression is used to estimate the odds that a characteristic is present given the values of explanatory variables (Greene, 2015). In this research, the probability of a crash resulting in a pedestrian fatality will be predicted based on the presence of specific crash characteristics (e.g. driver/pedestrian age, weather conditions, time of day, day of the week, travel speed, etc.). The statistical model is derived as follows:

Variables:

$Y_i = 1$ if a crash (i) resulted in a fatality

$Y_i = 0$ if a crash (i) did not result in a fatality

$X = (X_1, X_2, \dots, X_k)$ will be a set of explanatory variables which can be discrete, continuous, or a combination (outlined in Table 2). x_i is the observed value of the explanatory variables for observation i .

Model:

$$\pi_i = Pr(Y_i = 1 | X_i = x_i) = \frac{\exp(\beta_0 + \beta_1 x_i)}{1 + \exp(\beta_0 + \beta_1 x_i)}$$

or,

$$\begin{aligned} \text{logit}(\pi_i) &= \log\left(\frac{\pi_i}{1 - \pi_i}\right) \\ &= \beta_0 + \beta_1 x_i \\ &= \beta_0 + \beta_1 x_{i1} + \dots + \beta_k + \beta_k x_{ik} \end{aligned}$$

Assumptions:

- The data Y_1, Y_2, \dots, Y_n are independently distributed (cases are independent)
- Distribution of Y_i is $Bin(n_i, \pi_i)$, i.e., binary logistic regression model assumes binomial distribution of the response. The dependent variable does NOT need to be normally distributed, but it typically assumes a distribution from an exponential family (e.g. binomial, Poisson, multinomial, normal, etc.)
- Does NOT assume a linear relationship between the dependent variable and the independent variables, but it does assume linear relationship between the logit of the response and the explanatory variables; $logit(\pi) = \beta_0 + \beta X$
- Independent (explanatory) variables can even be the power terms or some other nonlinear transformations of the original independent variables.
- The homogeneity of variance does NOT need to be satisfied. In fact, it is not even possible in many cases given the model structure.
- Errors need to be independent but NOT normally distributed.
- It uses maximum likelihood estimation (MLE) rather than ordinary least squares (OLS) to estimate the parameters, and thus relies on large-sample approximations.
- Goodness-of-fit measures rely on sufficiently large samples, where a heuristic rule is that not more than 20% of the expected cells counts are less than 5 (Greene, 2015).

2.4 Summary

While Utah has a rather limited definition of what constitutes a “pedestrian”, the state code clearly outlines the roles and responsibilities of pedestrians and motor vehicles coming in contact with them. This is appropriate considering the increased risk faced by pedestrians and the rise in pedestrian fatalities over the past five years.

Utah’s population is significantly younger than the national average, and concomitantly the average age of a pedestrian killed in a crash is significantly lower than the national data. Elderly pedestrians are highly likely to be severely injured or killed as pedestrians. Men are the most likely to be involved in and killed in a pedestrian crash at both the state and national levels. Additionally, while urban areas experience more pedestrian crashes, crashes in rural Utah are more likely to involve a fatality.

A number of factors can significantly impact travel behavior, and therefore the likelihood of being involved in a crash as a pedestrian. Historically transportation planners have focused on the very young and very old as captive pedestrian groups and as vulnerable populations, however travel behavior trends have shown an increasing reliance on walking by millennials which increases the likelihood that these individuals will have a higher representation in pedestrian crashes and fatalities. Decision making also contributes to fatalities. Research has shown that a large number of fatalities occur when pedestrians attempt to cross the roadway away from an intersection, or when pedestrians or drivers are impaired or distracted in some way (alcohol, drugs, electronics, etc.). All of these factors will be examined in detail in the following sections.

This research will employ a number of statistical analysis methods to describe trends in the data as well as make predictions regarding correlation and causality between variables. Each method has been selected based on its appropriateness for use with this dataset, relative to the research questions and hypotheses. These methods will include using summary statistics, Pearson's Chi-Square, independent sample t-tests, and binary logistic regression models.

3.0 DATA COLLECTION

3.1 Overview

This project examined data in two main ways. The first emphasis was on data quality and the accuracy of the data provided by law enforcement in the crash reports, as well as the potential for integrating other data sources. The second emphasis of this project focused on analysis of the data that was provided and available. This chapter examines the first by identifying the data sources employed in this study and also by taking a preliminary look at data quality.

3.2 Crash Data

Utah collects data from traffic crash reports. These reports are completed by law enforcement officers who investigate crash scenes on public roads. Information is collected when a crash involves injuries, deaths, or at least \$1,500 property damage. Additional detailed information is collected on fatal crashes and compiled into the Fatality Analysis Reporting System (FARS). FARS is a national data system that collects data on all fatal traffic crashes in the U.S.

UDOT Traffic and Safety utilized FARS to compile data on fatal crashes and provided the project team with a database of crashes involving at least one pedestrian fatality. Within this database, 119 incidents occurring from 2012-2014 were selected for further in depth analysis. A separate secondary database was used to compare fatal to non-fatal crashes. This secondary dataset included crash report data for all crashes involving at least one pedestrian that occurred in Utah between 2006 and 2015. This database consists of characteristics for 17,353 pedestrians involved in 7,093 crashes resulting in 325 pedestrian fatalities (317 fatal incidents).

For the detailed fatality database, a number of sources were recruited to gather additional information relative to each incident. First, at each crash site the responding law enforcement officer will generally write up a narrative or summary of what occurred leading up to the crash. This provides the details identified through his/her investigation of the crash. For this research,

the officer’s narrative was used to both confirm and expand upon the coded data in the crash report. Second, UDOT Region 2 employs a Region Safety Coordinator. This individual is responsible for responding to any crash occurring within Region 2’s jurisdiction (Salt Lake, Summit, and Tooele Counties) that involves a fatality. At the scene, this individual creates a separate report and narrative based upon an independent investigation and discussion with the responding officer(s). Additionally, the Region Safety Coordinator examines any roadway or system related contributions to the crash. All other UDOT regions were contacted for similar information, however none reported having a system in place for dispatching a safety representative to fatal crashes. Lastly, an exhaustive online search was conducted to collect information from news media (electronic, print and television) relative to fatal pedestrian crashes within the sample. These reports were reviewed to determine if any additional information was provided. Table 1 shows the breakdown of available data sources for each crash included in the sample.

Table 1. Sources of Crash Data

| Data Source | % of Sample (n=119) |
|------------------------------------|--------------------------------|
| Original Crash Report | 100.0 |
| Supplemental Law Enforcement Notes | 88.0 |
| UDOT Safety Coordinator Notes | 51.3 |
| News Media Reports | 18.5 |

3.3 Crash Contributing Factors

After identifying a sample of all the fatal pedestrian crashes within the target time frame (2012-2014), an initial database was compiled including all of the original codes submitted on the crash report. This data outlines all contributing factors associated with each crash as input by the responding law enforcement officer. This includes all locational and environmental conditions as well as personal contributing factors identified for both the pedestrian and any involved vehicles. The database included the specific variables shown in Table 2.

Table 2. Crash Report Variables

| General Information | Environmental Conditions | Pedestrian Characteristics | Driver/Vehicle Characteristics |
|----------------------------|-------------------------------------|---------------------------------------|---|
| Crash ID | Light condition | Age | DUI |
| DLD Number | Weather condition | Injury area | Aggressive driving |
| Public Safety Case # | Roadway condition | Injury cause | Distracted driving |
| Date and Time (12 hr) | Roadway features | Non-motorist action | Drowsy driving |

| | | | |
|--------------------------|------------------------|---------------------------|----------------|
| Milepoint | Work zone/construction | Non-motorist contribution | Speed related |
| Route | | Non-motorist location | Teenage driver |
| City | | | Older driver |
| Location Description | | | |
| UTM x and y | | | |
| Manner of collision | | | |
| Roadway alignment | | | |
| # vehicles involved | | | |
| First harmful event | | | |
| Bicyclist involved | | | |
| Motorcycle involved | | | |
| Commercial vehicle | | | |
| Transit vehicle involved | | | |

Using data acquired from the supplementary data sources, additional variables were added to the dataset. They included:

- Day of the week (Mon-Sun)
- Time of Day (24 hour)
- Driver distraction (if known)
- Keywords that indicated the main cause of the crash or key characteristics

3.4 Data Quality

A crash report was available for all of the fatal crashes included in this sample. Supplemental sources were available for a portion of the sample. One key component of this research included determining the quality of the data provided on a typical crash report for a fatal pedestrian crash. An analysis of the data quality of the sample is provided in Section 4.2.

3.5 Summary

Two major databases are being used for this research. The first includes all pedestrian fatalities involving at least one vehicle that occurred from 2012-2014 (119 cases) as identified from the FARS database. The second database includes crash report data for all pedestrian crashes involving at least one vehicle from 2006-2015 (17,353 cases and 7,093 crashes).

Supplemental data was reviewed and added to the first fatality database. This included supplemental data collected through crash report narratives provided by the responding law enforcement officer, field notes from the UDOT region safety coordinator and details provided in news reports of each crash (when available). A contributing factor database was created for all

fatal crashes and additional characteristics were added, including day of the week, time of day (24 hour), specific driver distraction (if noted) and any key words that could be used to describe the crash (e.g. DUI, potential suicide, speed, etc.).

4.0 DATA EVALUATION

4.1 Overview

This section includes analysis of all crash reports and supplemental data. First data quality is examined. The remainder of the section is devoted to addressing the research questions posed in Section 1 relating to fatal crash characteristics, pedestrian fault, and timing.

4.2 Accuracy of Crash Data

4.2.1 Conflicting Data within a Report

Using the scene narrative provided by law enforcement, the crash report coding was double checked, and when errors or omissions were identified a separate variable was coded to indicate the correct coding for the crash. One common example was the coding of “non-motorist contribution” as “unknown” when in fact the pedestrian contribution was identified in the narrative section of the crash report. This recoding of crash reports identified a number of discrepancies between the coding on the report and the narrative provided by the officer at the scene and also often provided additional details. The following table shows the number of errors identified in the sample crash reports.

Table 3. Coding Errors on Crash Reports

| Number of Coding Errors | Number of Reports | % of Sample |
|--------------------------------|--------------------------|--------------------|
| 0 | 39 | 32.8 |
| 1 | 35 | 29.4 |
| 2 | 27 | 22.7 |
| 3 | 12 | 10.1 |
| 4 or more | 6 | 5.0 |
| | 119 | 100.0 |

As indicated in Table 3, only 33% of the crash reports contained no coding errors. Almost 40% of the crash reports analyzed contained 2 or more errors or omissions which could easily be clarified in the officer narrative from the scene (indicating that the officer had the

accurate data at the time of the crash investigation). This may signify a need for improved officer training on completing crash reports involving a pedestrian victim.

4.2.2 Information Omitted from a Report

In reviewing crash reports completed by law enforcement at the scene, a large discrepancy in the quality of detail and narrative was also found. On 12% of crash reports (n=14) the responding officer provided no diagram or narrative of the crash. In these cases it was not possible to double-check the accuracy of the coding, and the codes had to be taken at face value. With regards to pedestrian fatalities resulting from distracted driving, 23 cases were identified; but the report narrative only identified the distraction (i.e. texting, radio, etc.) for 14 cases. Overall, the level of detail provided varied widely based on the officer. In five cases additional data was acquired from news media sources reporting on the crash. Because in these cases the officer narrative was limited or missing, no quality control could be performed to double check the accuracy of the news reporting against the report of law enforcement (see example in Figures 1 and 2 below).

| | | | | | |
|---|--|---------------------------------------|--|------------------------------|--|
| ROAD, STREET, HWY CRASH OCCURRED 7800 South | | UDOT USE ONLY | | REPORTABLE | |
| LOCATION ON ROAD, STREET, HWY 0 feet W of 6300 West | | | | | |
| MILEPOST tenth(s) of a mile of Mile Post | | | | | |
| 05 Fatal | | 02 Dark - Lighted | | 99 Unknown | |
| 96 Not Applicable/No Work Zone | | 02 Wet | | 01 Straight | |
| 96 Not Applicable/No Work Zone | | 00 No Special Feature/Junction | | 02 Grade | |
| 96 Not Applicable/Single Veh | | 03 City | | 02 Asphalt (blacktop) | |
| 03 Road Surface Condition (wet, icy, snow, | | 99 Unknown | | 99 Unknown | |
| 03 Rain | | 04 Not Visible | | 22 Pedestrian | |
| Emergency personnel were dispatched on an auto vs. pedestrian crash. Officers responded and found that a westbound vehicle collided with a 44 year old adult male subject, riding in an electronic wheelchair. The adult male subject had an 11 year old male riding on the back of the electronic wheelchair at the time of the crash. The wheelchair and its occupants appear to have been hit from behind, while they were traveling westbound. Both the 44 year old adult male and the 11 year old male were deceased as a result of the crash. Vehicle #1 sustained damage to the passenger side front corner of the vehicle. The case is under investigation. See long form report in Spillman for further. | | | | | |

Figure 1. Crash Report Involving Pedestrian Fatalities (Crash ID 10696596)

Media reports of the crash report shown in Figure 1 were widespread, as it involved a child riding on the back of his father’s motorized scooter. Several stories of this crash appeared on various television news outlets as well as on several online sites (See example in Figure 2). The media reports provided a wealth of detail that was not included in the officer’s crash report from the scene, including interviews with witnesses. The research team inquired of one news station (KSL 5 in Salt Lake City) regarding how they acquire their data at crash sites. They responded that typically the reporter will talk with the law enforcement officer on the scene to gather information for their report. That suggests that, at least for the example shown above, the officer at the scene was able to provide the media with a detailed narrative of what happened and the contributing factors, but was unable to communicate that same information in his crash report.

Man in wheelchair, boy killed in auto-pedestrian accident

By Jordan Ormond and Sandra Yi | Posted Dec 13th, 2014 @ 11:59pm

7 photos 42     



10PM: Man in wheelchair, boy killed in auto-pedestrian accident

WEST JORDAN — Two people are dead following an auto-pedestrian accident on 7800 South near the Mountain View Corridor (6300 West).

At around 5:30 p.m., Salt Lake Valley dispatchers received a call reporting the auto-pedestrian accident, West Jordan Police Sgt. Dan Roberts said.

When emergency workers arrived, they found man in an electric wheelchair and a "small boy" had been hit by a car, Roberts said. They both died at the scene.

Figure 2. News Report of Crash Involving Pedestrian Fatalities (Crash ID 10696596)

One potential argument could be made that the media may be embellishing their reports or filling in the missing details to create a more elaborate picture of the circumstances of a given crash. However, the project team compared news media reports against notes provided by the Region 2 Safety Coordinator. In all of the cases where notes from the Coordinator and a media report were available, the media reports were found to be accurate and consistent with UDOT's notes from the scene. Overall the Utah Highway Patrol had the most comprehensive reports with the highest level of detail in both the narrative and crash diagrams (See Figure 3 below). This is likely due to their investment in crash reconstruction training and their focus on highway safety and experience in responding to crashes.

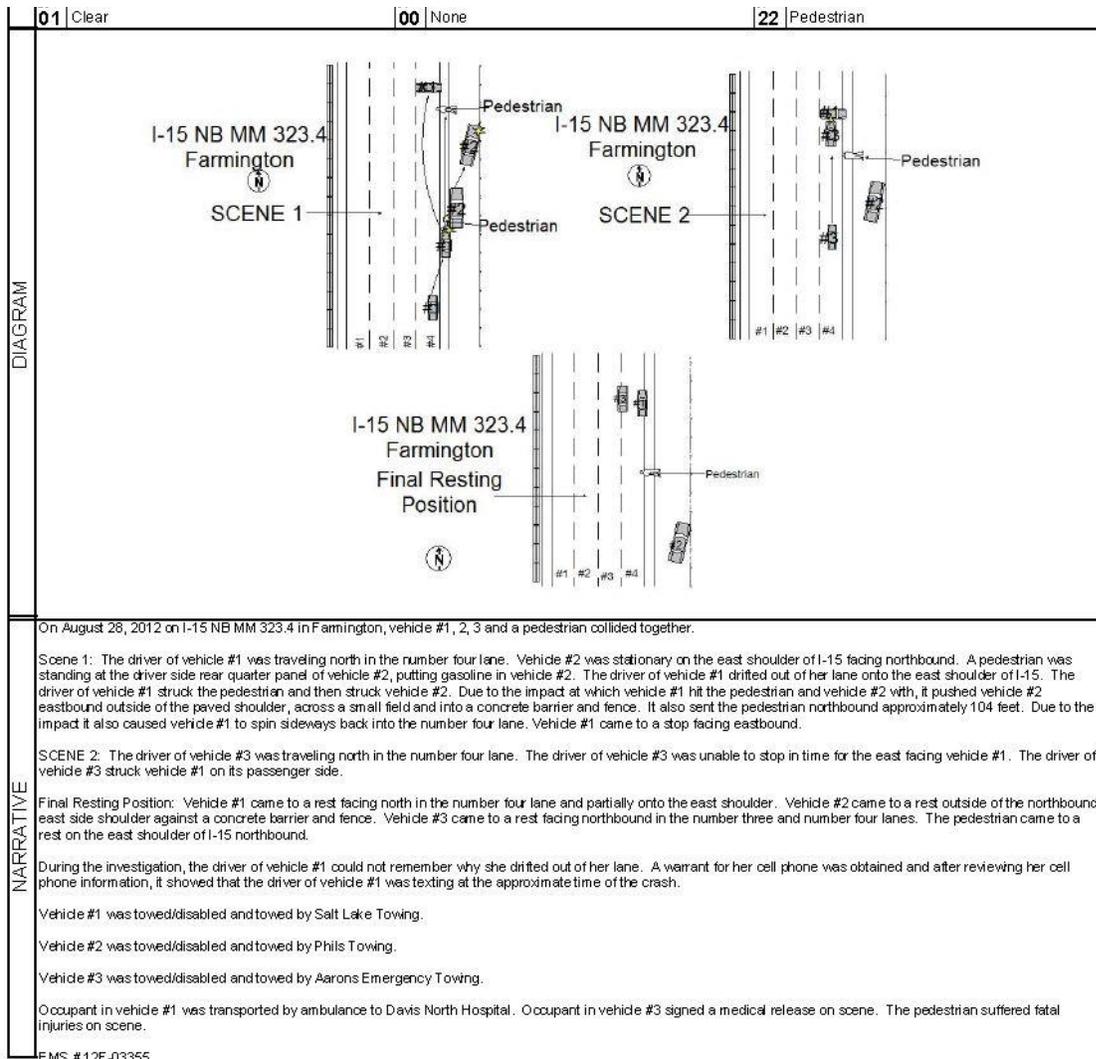


Figure 3. Crash Report with High Level of Detail

4.3 Summary Characteristics of Pedestrian Fatalities

The first analysis step was to identify common characteristics among fatal pedestrian crashes for both drivers and pedestrians. This section outlines the most common characteristics identified through a summary analysis.

4.3.1 General Conditions

Using summary statistics we can easily determine which conditions and characteristics stand out for fatal pedestrian crashes. This section is not intended to relate cause or correlation,

but to simply summarize the data. Comprehensive analysis is provided in the subsequent sections of Chapter 4.

The first factor that was examined in this summary analysis were the weather conditions at the time of fatal crashes. Intuitively one would assume that poor weather could increase the likelihood of pedestrian crashes and may also increase their severity due to limited visibility, wet or slick roads, etc. Table 4 below shows that for a large majority of all pedestrian crashes (fatal and non-fatal) the weather was clear or cloudy. Approximately 10.1% of fatal crashes occurred during inclement weather (rain, snow, fog, etc.) compared to 8.1% for all pedestrian crashes. In 12.3% of fatal crashes the roadway was wet and in 2.8% the roadway was icy. A statistical analysis of the distribution of crash severity and weather conditions revealed that there is a significant difference in the distribution of fatal vs non-fatal crashes when accounting for weather (*Chi Square*=103.58, *sig.* = 0.000).

Table 4. Weather Conditions at Time of Crash

| Weather | % of All Ped Crashes | % of Fatal Crashes |
|-------------------|----------------------|--------------------|
| Clear | 76.1 | 75.4 |
| Cloudy | 13.6 | 11.2 |
| Raining | 5.2 | 7.3 |
| Snowing | 2.8 | 1.7 |
| Sleet/Hail | 0.1 | 1.1 |
| Severe Crosswinds | 0.0 | 0.6 |
| | n=7,093 | n=119 |

A second general condition that was considered was the presence of construction on the roadway. Construction may create uncertainty in travel behavior for both the pedestrian and the driver which could lead to an increase in crash rates or severity. The data shows that 6.7% of fatal crashes occurred during road construction; specifically during a lane closure. No other types of construction were identified at the time of fatal pedestrian crashes.

4.3.2 Vehicle Characteristics at Time of Crash

An examination of fatal pedestrian crashes can yield greater insight into the contribution of both the driver and the pedestrian involved. One key component is the vehicle maneuver just prior to the crash. Automobiles traveling straight ahead pose the greatest risk for a fatal crash (77.9% - see Table 5). Left turns were the second most prevalent (6.3%), followed by parked

cars pulling out (5.4%) or backing up (2.2%). Approximately 8% of vehicles involved in a fatal pedestrian crash were pulling a trailer or towing another motor vehicle at the time of the crash. This runs in contrast to the most common vehicle maneuvers for non-fatal pedestrian crashes (shown side-by-side for comparison). While right turning vehicles account for nearly one in five pedestrian crashes, only 2.5% of fatal crashes result from a right turning vehicle. A Pearson's Chi-Square test found a significant difference the vehicle maneuvers in fatal vs non-fatal crashes (*Chi-Square*=578.693, *sig.*=0.000).

Table 5. Vehicle Maneuver Prior to Fatal Pedestrian Crash

| Vehicle Maneuver | % of All Ped Crashes | % of Fatal Crashes |
|-------------------------|----------------------|--------------------|
| Straight Ahead | 52.6 | 77.9 |
| Turning Right | 18.1 | 2.5 |
| Turning Left | 16.2 | 6.3 |
| Parked | 2.4 | 5.4 |
| Backing | 3.6 | 2.2 |
| Slowing in Traffic Lane | 1.6 | 1.9 |
| Changing Lanes | 0.9 | 1.3 |
| | n=7,093 | n=317 |

The speed of the vehicle at the time of the crash was also considered. By subtracting the actual travel speed at the time of the crash from the posted speed limit on the roadway, a speeding rate was calculated. Speed rate is a more appropriate measure than travel speed because it takes into account variability in the posted speed limit. A speed rate can provide behavioral information on how fast the vehicle was traveling relative to the posted speed limit regardless of what that limit may be. In fatal pedestrian crashes, the average speeding rate was 3.6. This means that on average, a vehicle was traveling 3.6 miles per hour over the posted speed limit at the time of the crash. An independent samples T-Test found a significant difference between the speeding rates of non-fatal crashes and fatal pedestrian crashes ($t=4.328$, *sig.*=0.000). For a majority of pedestrian crashes, vehicles were traveling well below the posted speed limit (Speed rate= -14.62) at the time of the crash. Vehicles involved in a fatal pedestrian crash were traveling almost 18 mph faster, on average, than in non-fatal crashes.

4.3.3 Driver Contribution

A number of different individual contributing factors were identified in both the coded reports and the crash narratives. Table 4 outlines the driver contributions to fatal pedestrian crashes. This does not indicate that the driver was solely at fault, but simply that they contributed to the crash. The pedestrian may also have contributed to the crash in each case. This will be elaborated on in Section 4.4.

Table 6. Driver Contributing Factors*

| Driver Contribution | % of Crashes |
|----------------------------|---------------------|
| Distracted Driving | 19.3 |
| Driver DUI | 9.5 |
| Speeding | 5.6 |
| Drowsy Driving | 1.7 |
| Aggressive Driving | 0.6 |
| | n=119 |

*Detailed contributing factors were not available for all pedestrian crashes.

As shown in Table 6, the number one driver contribution was distracted driving (nearly 20% of cases). The most frequently cited distractions were: cell phones (texting or talking-43%), adjusting the radio (14.2%), and the glare of the sun (14.2%). Driving under the influence, speeding, drowsy driving, and finally aggressive driving were also contributing factors. Driver age did not seem to play a significant role in contributing to fatal crashes as only 20% of fatal crashes involved a teen driver (age 16-19, 10%) or an older driver (age 65+, 10%).

4.4 Pedestrian Contributions to Fatal Crashes

One of the key aspects of this research, is to examine the role that pedestrians themselves play in determining the occurrence or severity of a crash involving an automobile. A great deal of attention is paid to a driver's contribution to a crash, however a pedestrian must be held equally responsible for obeying traffic laws and signals, and traveling in a safe manner.

4.4.1 Dangerous Behaviors

In a majority of the fatal crashes examined in this study, the pedestrian directly contributed to the fatal crash (78.8%). In nearly half of all cases, at the time of the crash the

pedestrian was entering or crossing the road (47%), or participating in some other activity in the roadway (20%). Rarely was the pedestrian traveling on the shoulder or sidewalk.

Table 7. Pedestrian Contribution to Crash

| Non-Motorist Action | % of All Ped Crashes | % of Fatal Crashes |
|----------------------------|-----------------------------|---------------------------|
| None | 20.6 | 20.3 |
| Improper Crossing | 7.4 | 21.5 |
| Darting | 4.3 | 6.2 |
| Not Visible | 2.3 | 8.0 |
| In Roadway Improperly | 2.8 | 10.1 |
| | n=17,353 | n=325 |

Table 7 outlines pedestrian contributions to all crashes as well as specific contributions to fatal crashes. Pedestrians crossing or standing in the roadway improperly were the top contributing factors to fatal crashes (31.6%). In 21.5% of fatal crashes the pedestrian was improperly crossing the roadway compared to only 7.4% of all pedestrian crashes. In a majority of cases, one of these pedestrian contributing factors occurred simultaneously with a driver contributing factor creating a deadly combination of dangerous behavior. A Pearson’s Chi-Square Test shows that a non-motorist’s action at the time of the crash differs significantly in fatal and non-fatal crashes (*Chi-Square*=363.901, *sig.*=0.000).

It is interesting to note that these contributing factors line up almost directly with the five key factors that NHTSA identified as contributing to a higher risk of a pedestrian being involved in a collision resulting in severe injuries or death (NHTSA, 2004). They were: excessive speed, conflicts at crossings (failure to yield right-of-way), inadequate conspicuity (not visible), poor compliance with laws (improper crossing, in roadway improperly, failure to obey traffic signs/signals, etc.), and inadequate separation.

4.4.2 Pedestrian Age

There is a relatively even distribution across age groups for crash victims (shown in Figure 4) with some clustering in the late teens/early twenties. After age 50 the frequency of pedestrian fatalities drops dramatically (with the exception of a spike around age 65). This is likely due to a drastic reduction in walking/exposure for individuals as they age.

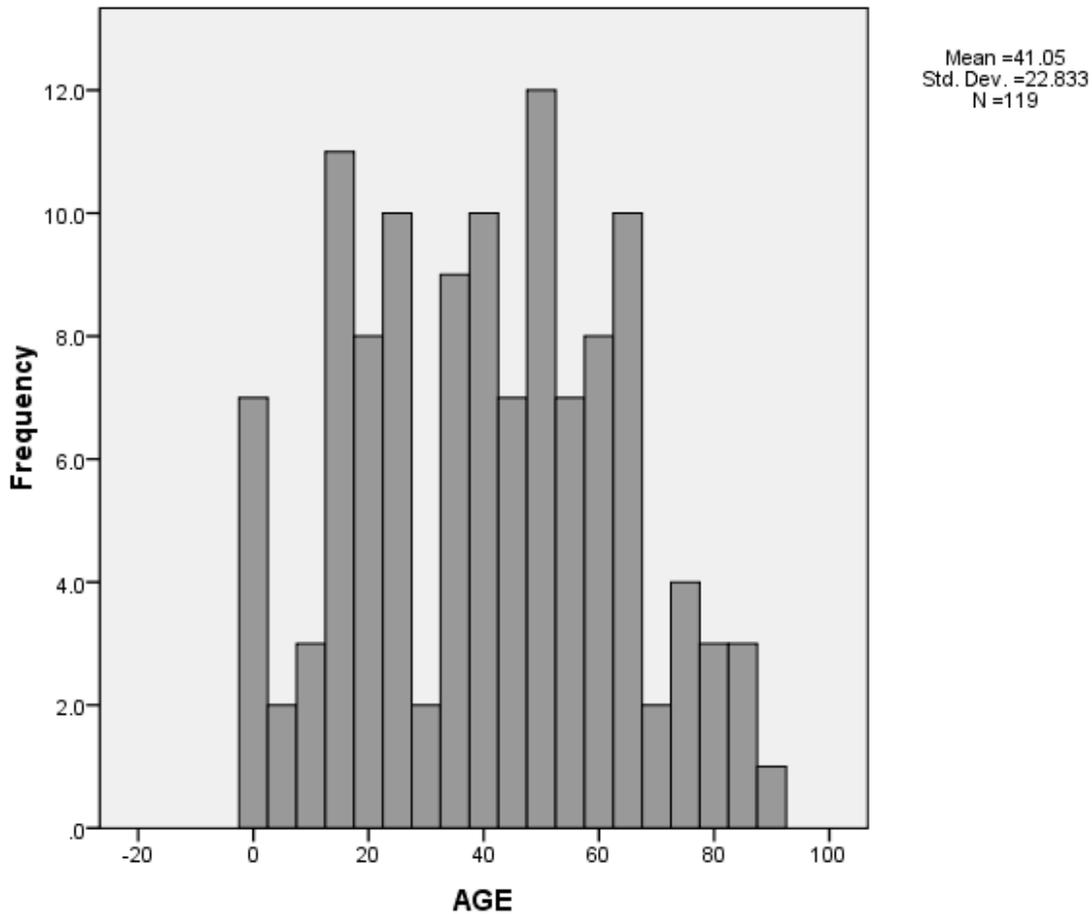


Figure 4. Age of Pedestrian Involved in Fatal Crash

However, an independent samples T-test found a significant difference in the age of the pedestrians involved in fatal vs non-fatal crashes. Pedestrians killed in crashes are significantly older than the sample of pedestrians involved in call crashes ($t=-4.017$, $sig.=0.000$). The average age of a pedestrian involved in a crash is 28, while the average pedestrian killed in a crash is 42 years old.

4.5 Timing Characteristics of Fatal Pedestrian Crashes

Approximately 40% of pedestrian fatalities occurred on or around the weekend (Friday through Sunday, which is consistent with an even distribution. However, while Saturday and Monday exhibited a significantly higher number of pedestrian fatalities, Friday and Sunday

actually show significantly fewer fatalities. Mid-week saw the lowest incidence of fatal pedestrian crashes (Tuesday-Thursday).

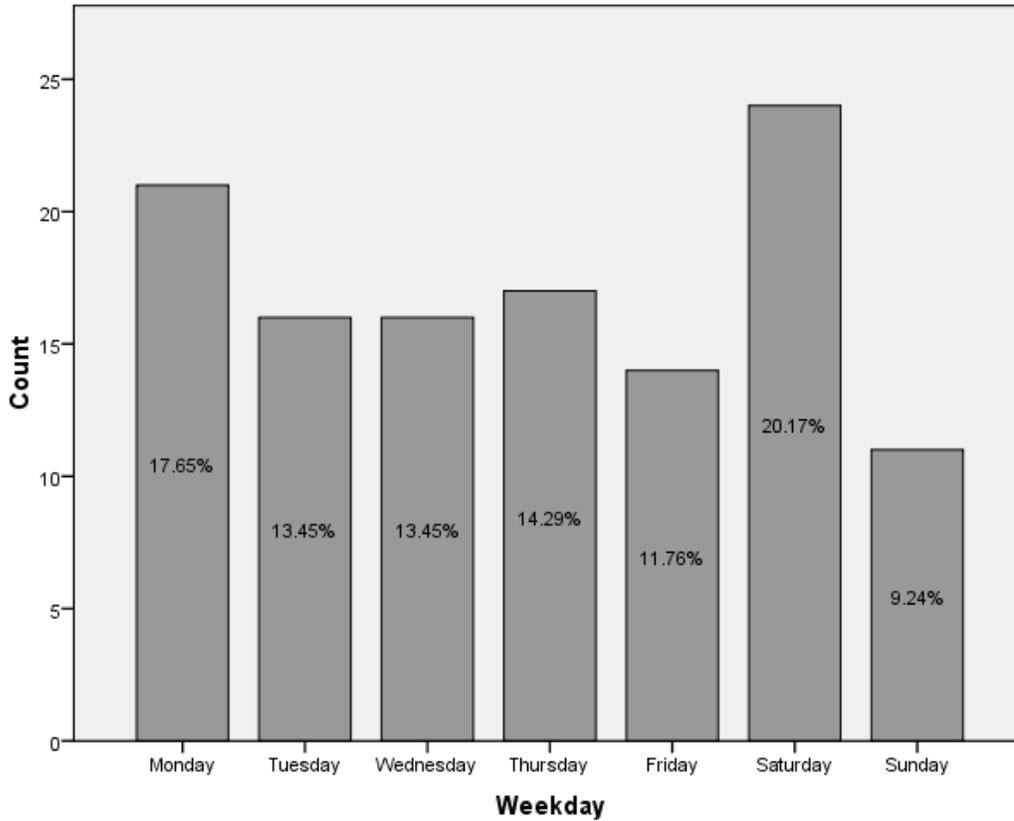


Figure 5. Fatal Pedestrian Crash Occurrence- by Day of the Week

A Chi-Square analysis found that fatality rates do not differ significantly between fatal crashes and non-fatal crashes by day of the week ($Chi-Square=12.45$, $sig.=0.053$). Figure 6 below shows that the distribution of pedestrian crashes is relatively consistent with a marked decrease on the weekends.

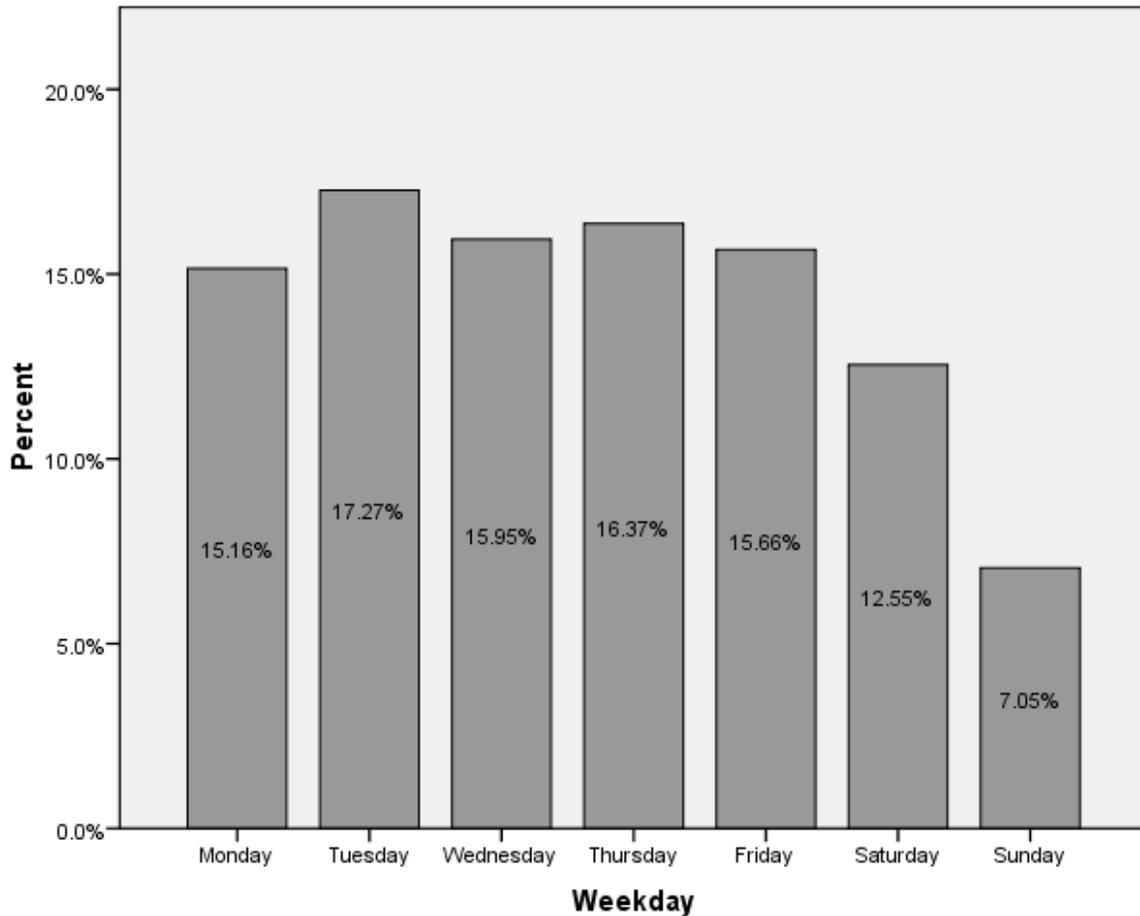


Figure 6. Pedestrian Crash Occurrence- by Day of the Week

Time is also an important factor when considering crash severity. National data has shown that over half of all pedestrian fatalities occur between 6:00pm and midnight (NHTSA, 2016). While a large majority of pedestrian crashes in Utah occur between 2:00pm and 7:00pm, fatal crashes are more likely to occur later in the evening. Figure 7 shows a cluster pattern of fatal pedestrian crashes occurring between 5:00pm and 7:00am during lower light/dark conditions. An analysis of light conditions found that only 25% of fatal crashes occurred during daylight, whereas 66.9% of fatal crashes occurred in the dark and 5.5% occurred at dawn or dusk.

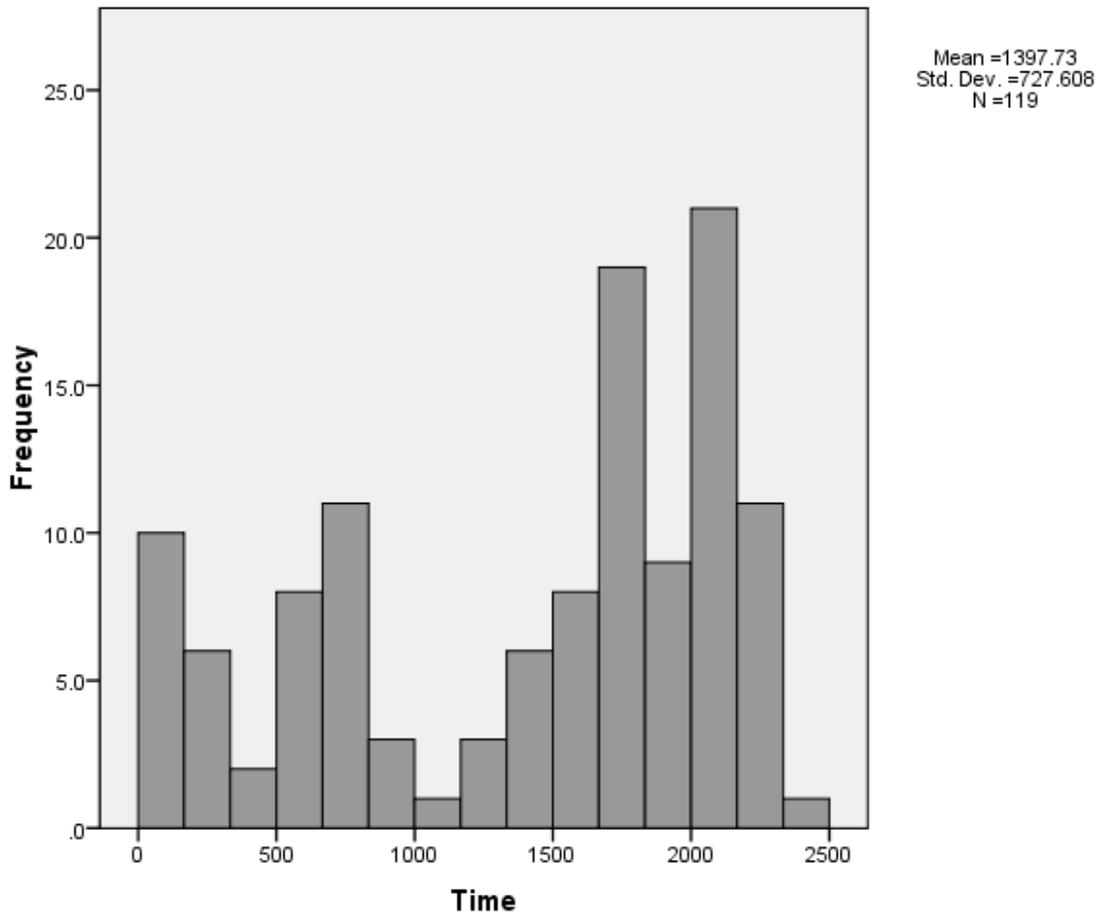


Figure7. Fatal Crash Frequency by Time of Day

Time of year also seems to contribute to fatal pedestrian crashes. As Figure 8 shows, over one half of all fatal pedestrian crashes occurred in the early Spring (March-April: 26.05%) or late Fall (October-November: 25.21%).

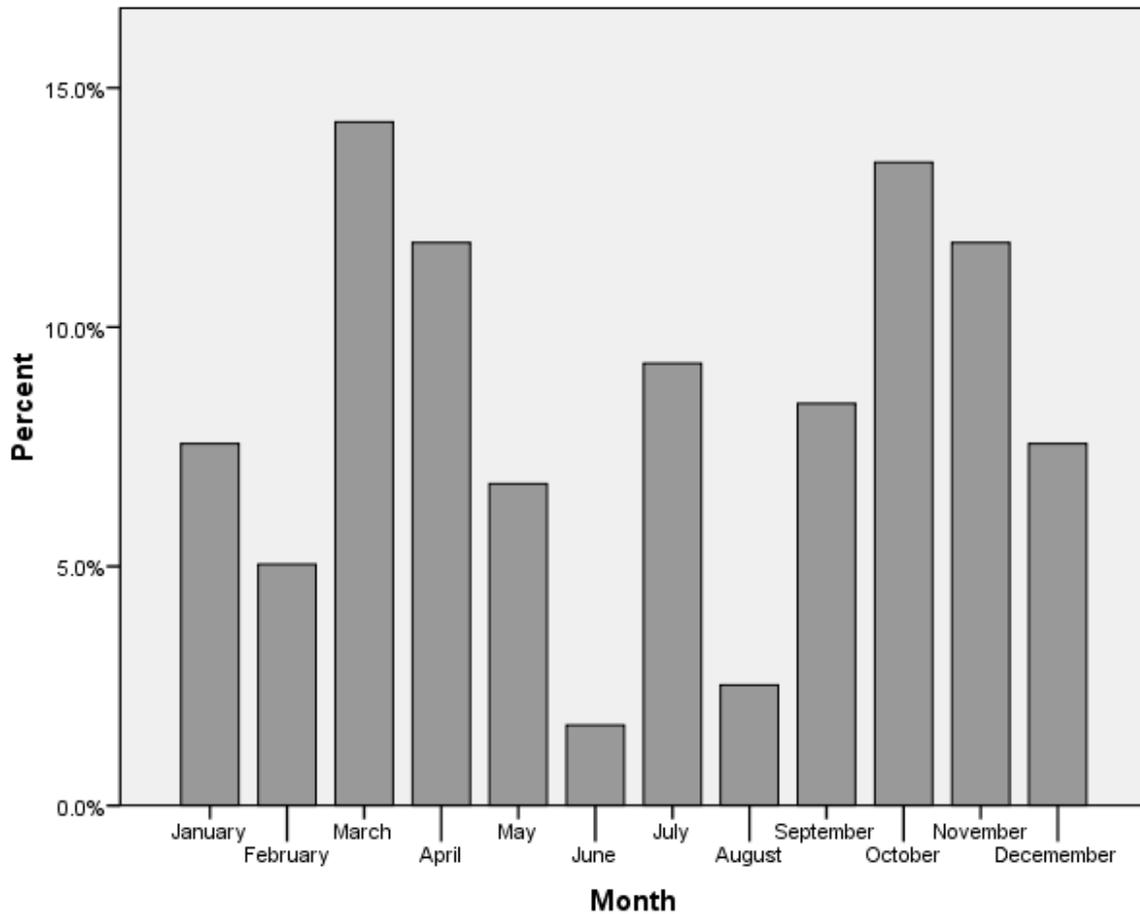


Figure 8. Fatal Pedestrian Crash Frequency- by Month

A Chi-Square analysis found that fatality rates differ significantly by time of year from the rate for all pedestrian crashes (*Chi-Square*=33.472, *sig.*=0.000). There is a spike in fatalities occurring in July, although the remainder of the summer saw very low rates of fatal crashes. This differs significantly from the distribution of all pedestrian crashes shown in Figure 9 below.

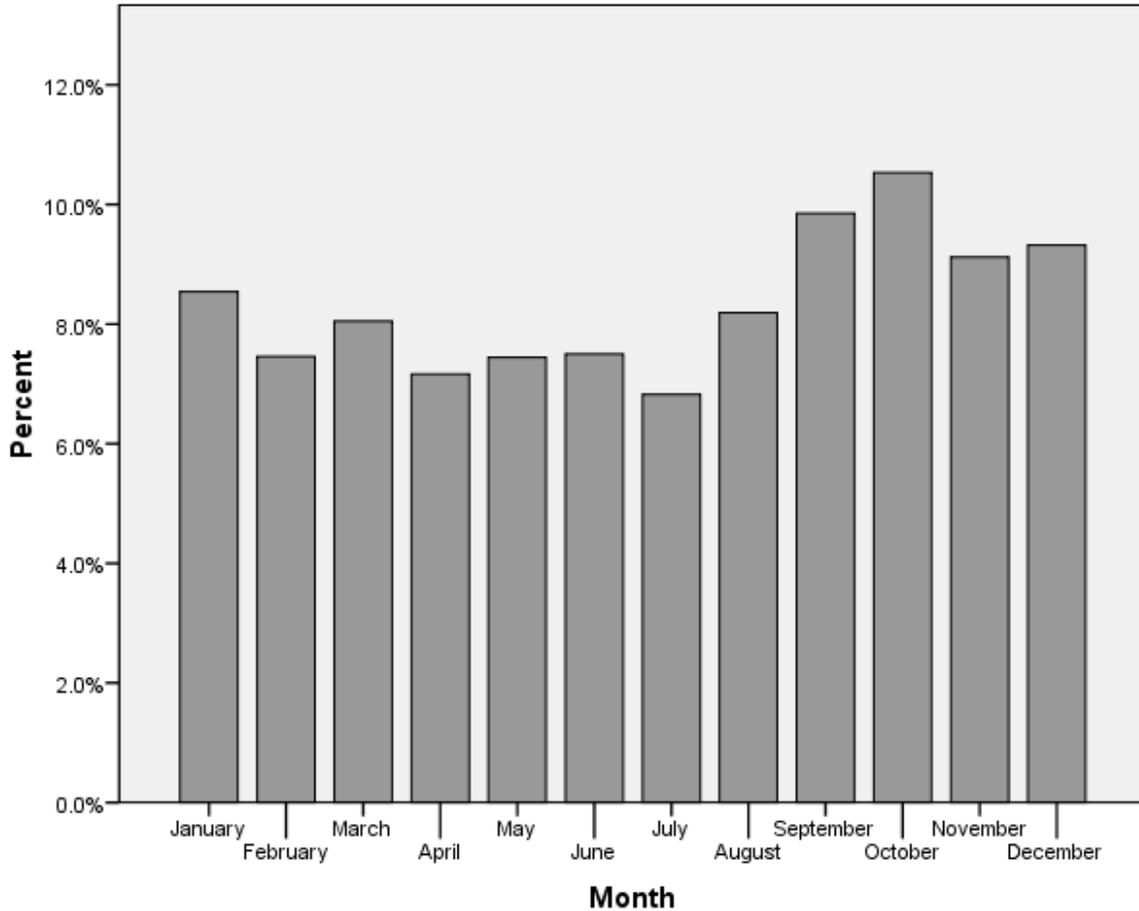


Figure 3. Pedestrian Crash Frequency- by Month

Total pedestrian crash rates are relatively consistent month-to-month with a slight increase in the early Fall. This is consistent with the beginning of school and an increase in walking/exposure.

4.6 Fatal vs Non-Fatal Crashes

The analysis shown in the prior sections paints a compelling picture of what makes a fatal pedestrian crash unique, however these statistics cannot provide significant evidence to show what actions or characteristics will result in a fatal crash.

Based upon the analysis of contributing factor presented in Section 4.3.1, a subsequent more statistically complex analysis was conducted to identify if specific environment factors could predict an increase in fatal pedestrian crashes. A Binary Logit Regression Model (using maximum likelihood estimation) was employed to identify the marginal effects that specific lighting, weather, and pavement conditions had on pedestrian crash fatality rates.

Table 8. Logit Model of General Conditions

| Variable | B | Std. Error | Sig. | Exp(B) | 95% Confidence Interval | |
|-------------------|--------------------------------------|------------|-------|--------|-------------------------|-------------|
| | | | | | Lower Bound | Upper Bound |
| Light Condition* | | | | | | |
| Daylight | -2.069 | 0.721 | 0.004 | 0.255 | 0.031 | 0.519 |
| Dark (lighted) | -0.669 | 0.648 | 0.302 | 0.379 | 0.114 | 1.825 |
| Dark (no lighted) | 0.097 | 0.647 | 0.881 | 0.955 | 0.310 | 3.916 |
| Dawn | -0.807 | 0.715 | 0.259 | 0.410 | 0.105 | 2.43 |
| Dusk | -1.122 | 0.717 | 0.117 | 0.287 | 0.110 | 1.811 |
| Weather* | | | | | | |
| Clear | -0.449 | 0.644 | 0.485 | 0.692 | 0.181 | 2.253 |
| Cloudy | -0.500 | 0.661 | 0.450 | 0.675 | 0.166 | 2.215 |
| Rain | -0.706 | 0.717 | 0.325 | 0.869 | 0.121 | 2.014 |
| Sleet/Hail | 40.530 | 1.244 | 0.002 | 45.600 | 3.985 | 521.798 |
| Snow | -0.669 | 0.791 | 0.397 | 0.640 | 0.109 | 2.413 |
| Roadway Surface* | | | | | | |
| Dry | 1.120 | 0.800 | 0.167 | 2.534 | 0.627 | 14.977 |
| Wet | 1.264 | 0.847 | 0.136 | 2.289 | 0.672 | 18.629 |
| Snow | 0.861 | 0.986 | 0.383 | 2.054 | 0.342 | 16.342 |
| Ice | 1.485 | 0.918 | 0.106 | 3.981 | 0.729 | 26.701 |
| Number of Lanes | 0.050 | 0.016 | 0.002 | 1.052 | 1.022 | 1.108 |
| | <i>Chi-Square=23.956, Sig.=0.021</i> | | | | <i>n=7,093</i> | |

Three environmental factors were shown to significantly predict fatal crashes; lighting condition, specific weather, and number of roadway lanes (Table 8). The odds of a fatal crash occurring during daylight are 75% lower than in other light conditions. The odds of a fatal crash occurring during sleet/hail are 45.6 times higher than during other types of weather. Each additional lane present on a given roadway increases the odds of a pedestrian crash being fatal by 5%.

Several characteristics of driver contribution were also considered. Specifically speeding rate and vehicle maneuver at the time of the crash. As a reminder, the speeding rate is calculated by subtracting the posted speed limit from the actual speed of travel at the time of the crash. This tells us the degree to which a driver is speeding. If a driver is speeding the value will be positive. If the driver is traveling under the speed limit, the value will be negative. This

provides a more accurate calculation than raw speed because it standardizes values for speeding behavior regardless of the location.

Table 9. Logit Model of Driver Contributions

| Variable | B | Std. Error | Sig. | Exp(B) | 95% Confidence Interval | |
|------------------|--------|------------|-------|---|-------------------------|-------------|
| | | | | | Lower Bound | Upper Bound |
| Speeding Rate | 0.005 | 0.002 | 0.001 | 1.005 | 1.003 | 1.013 |
| Vehicle Maneuver | | | | | | |
| Straight Ahead | -0.447 | 1.057 | 0.673 | 0.640 | 0.081 | 5.083 |
| Backing | -.293 | 1.134 | 0.254 | 0.275 | 0.030 | 2.532 |
| Changing Lanes | -0.471 | 1.213 | 0.698 | 0.624 | 0.058 | 6.723 |
| Turning Right | -2.911 | 1.125 | 0.010 | 0.054 | 0.006 | 0.494 |
| Turning Left | -1.795 | 1.082 | 0.097 | 0.166 | 0.020 | 1.383 |
| Parked | 0.266 | 1.091 | 0.807 | 1.305 | 0.154 | 11.062 |
| | | | | <i>Chi-Square</i> =161.757, <i>Sig.</i> =0.000 <i>n</i> =7,093 | | |

The model found that speeding rate was significantly correlated to fatality risk. For every 10 mph the speeding rate increased, the odds of a crash being fatal increased by 5%. Additionally, right turning movements were found to be negatively correlated to fatal crash risk. The odds of a fatal crash occurring when a vehicle is turning right is 95% lower than all other vehicle maneuvers.

Table 10. Logit Model of Pedestrian Contributions

| Variable | B | Std. Error | Sig. | Exp(B) | 95% Confidence Interval | |
|---------------------------|--------|------------|-------|--|-------------------------|-------------|
| | | | | | Lower Bound | Upper Bound |
| Sex | -0.067 | 0.118 | 0.573 | 0.935 | 0.742 | 1.180 |
| Age | 0.025 | 0.003 | 0.000 | 1.025 | 1.020 | 1.030 |
| Non-Motorist Contribution | | | | | | |
| Improper Crossing | 0.191 | 0.228 | 0.404 | 1.210 | 0.774 | 1.893 |
| Darting | -0.467 | 0.294 | 0.111 | 0.627 | 0.353 | 1.114 |
| Not Visible | 0.455 | 0.275 | 0.099 | 1.576 | 0.918 | 2.703 |
| In Roadway Improperly | 0.524 | 0.259 | 0.044 | 1.688 | 1.015 | 2.807 |
| | | | | <i>Chi-Square</i> =413.694, <i>Sig.</i> =0.000 <i>n</i> =17,353 | | |

An additional logit model of pedestrian contributions identified that age and improper crossings were significantly correlated to the likelihood of fatality (Table 10). For every decade older a pedestrian is, the odds of the crash being fatal increases by 25%. Being in the roadway improperly increases the odds of a pedestrian fatality by nearly 70%.

The final analysis examined the correlation between crash timing and fatality risk. For this model, Wednesday and September were used as reference categories due to their crash distribution characteristics. The model found that the odds of a fatal pedestrian crash occurring on Saturday or Sunday are nearly 57% higher than mid-week. Likewise, the odds of a fatal pedestrian crash occurring in March (1.74), July (1.96), October (1.89), and December (2.29) are 74-129% higher than one occurring in September.

Table 11. Logit Model of Crash Timing

| Variable | B | Std. Error | Sig. | Exp(B) | 95% Confidence Interval | |
|---------------|---------------------------------------|------------|-------|--------|-------------------------|-------------|
| | | | | | Lower Bound | Upper Bound |
| Day of Week | | | | | | |
| Monday | -0.043 | 0.216 | 0.843 | .958 | 0.627 | 1.464 |
| Tuesday | 0.040 | 0.206 | 0.848 | 1.040 | 0.694 | 1.559 |
| Thursday | 0.001 | 0.210 | 0.996 | 1.001 | 0.663 | 1.511 |
| Friday | -0.134 | 0.219 | 0.539 | 0.874 | 0.570 | 1.342 |
| Saturday | 0.445 | 0.205 | 0.030 | 1.561 | 1.045 | 2.331 |
| Sunday | 0.451 | 0.239 | 0.059 | 1.570 | 0.983 | 2.508 |
| Month of Year | | | | | | |
| January | 0.490 | 0.287 | 0.087 | 1.633 | 0.931 | 2.865 |
| February | -0.399 | 0.374 | 0.287 | 0.671 | 0.322 | 1.398 |
| March | 0.559 | 0.287 | 0.052 | 1.749 | 0.996 | 3.069 |
| April | 0.537 | 0.296 | 0.070 | 1.710 | 0.957 | 30.56 |
| May | 0.363 | 0.304 | 0.233 | 1.438 | 0.792 | 2.611 |
| June | -0.347 | 0.364 | 0.341 | 0.707 | 0.346 | 1.443 |
| July | 0.671 | 0.290 | 0.020 | 1.957 | 1.19 | 3.452 |
| August | -0.053 | 0.328 | 0.873 | 0.949 | 0.499 | 1.806 |
| October | 0.635 | 0.269 | 0.018 | 1.886 | 1.113 | 3.197 |
| November | 0.481 | 0.285 | 0.092 | 1.617 | 0.925 | 2.827 |
| December | 0.828 | 0.268 | 0.002 | 2.289 | 1.355 | 3.868 |
| | <i>Chi-Square=413.694, Sig.=0.000</i> | | | | <i>n=7,093</i> | |

* Wednesday and September used as reference Categories

4.7 Summary

A large majority of reports from fatal pedestrian crashes are inaccurate, most commonly containing coding errors and a lack of detail/officer narrative. Only 33% of the reports analyzed contained no errors. 15% of the crash reports involving a pedestrian fatality contained three or more coding errors.

When examining characteristics of fatal pedestrian crashes, the analysis found that over 10% of fatal pedestrian crashes occurred during inclement weather with wet or icy roads. The weather differed significantly during fatal vs non-fatal pedestrian crashes.

Vehicle maneuvering at the time of the crash significantly differed between fatal and non-fatal pedestrian crashes as well. In 78% of fatal crashes the vehicle was traveling straight. This was significantly more common than when a vehicle was turning (left turns - 6.3%; right turns - 2.5%). Speed also played a significant role. Vehicles involved in fatal pedestrian crashes were found to be traveling significantly faster than vehicles involved in non-fatal crashes.

Drivers contributed to the cause of the fatal crash in a majority of cases and were most likely to be distracted (20%), driving while intoxicated (9.5%) or speeding (5%). Pedestrians often contributed to fatal crashes as well. The most common pedestrian actions included improper crossing of the roadway (21.5%). Lack of visibility (8%), and being improperly in the roadway (10%) were also common contributors to fatal crashes. Both pedestrian and driver behaviors differed significantly between fatal and non-fatal pedestrian crashes.

The age of the pedestrian significantly differs in fatal vs non-fatal pedestrian crashes. Pedestrians killed in a crash are on average 14 years older than those who survive a crash. There is no significant difference between fatal and non-fatal crash distribution by day of the week, however, there is a significant difference by time of year. Fatal pedestrian crashes occur more often in the early spring and late fall. There are significantly fewer fatal pedestrian crashes in the summer, with the exception of a spike in July.

Logit models of several characteristics were able to significantly predict if a pedestrian crash would be fatal. The odds of a fatal crash occurring in daylight, or while a vehicle is turning right are significantly lower than at night or when traveling straight. Crashes occurring in bad weather (sleet/hail), on roadways with more lanes, when the driver is speeding and when the pedestrian is improperly in the roadway are significantly more likely to be fatal. Additionally, the older a pedestrian is, the more likely the crash is to be fatal.

Lastly, crash timing was significantly correlated to fatality risk. The odds of a fatal crash occurring on Saturday and Sunday are significantly higher than one occurring mid-week. The

odds of a fatal crash occurring in March, July, October, and December were higher than in September.

5.0 CONCLUSIONS

5.1 Summary

This research has sought to improve UDOTs understanding of pedestrian crashes resulting in a fatality by examining fatal incidents in further detail. Using crash report narratives (rather than the standard report form) as well as witness statements and other notes from the scene, combined with information from news reports made at the time, this research has sought to improve understanding of the circumstances that result in a pedestrian fatality, by identifying the following:

- What limitations are exhibited in current pedestrian crash reporting?
- Do pedestrian fatalities have commonalities in crash characteristics?
- What role does pedestrian fault play in fatal pedestrian crashes?
- Are pedestrian fatalities more common on certain days or at certain times?
- Are there significant differences between fatal and non-fatal crashes?

Two major databases were used for this research. The first included all pedestrian fatalities involving at least one vehicle that occurred from 2012-2014 (119 cases) as identified from the FARS database. The second database includes crash report data for all pedestrians involved in a crash involving at least one vehicle from 2006-2015 (17,353 cases and 7,093 crashes). Supplemental data was reviewed and added to the first fatality database. This included data collected through crash report narratives provided by the responding law enforcement officer, field notes from the UDOT region safety coordinator, and details provided in news reports of each crash (when available). A contributing factor database was created for the 2012-2014 fatal crashes and additional characteristics were added, including day of the week, time of day (24 hour), specific driver distraction (if noted) and any key words that could be used to describe the crash (e.g. DUI, potential suicide, speed, etc.).

This research has employed a variety of appropriate statistical analysis methods to describe trends in the data as well as make predictions regarding correlation and causality between variables. These methods include summary statistics, Pearson's Chi-Square, Independent Sample t-Tests, and Binary Logistic Regression Models.

Section 5.2 provides an overview of the findings from this research including a detailed discussion of the analysis presented in Section 4. Section 5.3 explains the limitations and drawbacks identified in this study and provides suggestions for future research.

5.2 Findings

This research has examined fatal pedestrian crashes in substantial detail in an effort to better understand factors that contribute to fatal crashes as well as how fatal crashes are reported.

5.2.1 Errors in Crash Report Coding

This research found that a large majority of reports from fatal pedestrian crashes are inaccurate, most commonly containing coding errors and a lack of detail/officer narrative. Only 33% of the reports analyzed contained no errors. 15% of the crash reports involving a pedestrian fatality contained three or more coding errors.

These errors and inaccuracy can be attributed to two main things: 1) The crash report itself is not set up to adequately deal with pedestrians involved in a crash, and 2) responding law enforcement are not appropriately trained to deal with investigating and reporting on crashes involving pedestrians.

The information required for a pedestrian involved crash in the current Utah Crash Report is not clearly identified, and specific critical characteristics can be overlooked. Many of the characteristics identified on the report are not mutually exclusive. On the crash form under "non-motorist action" there are 11 specific identifiable options. These include options relative to where the pedestrian is traveling (e.g. walking on sidewalk, waiting to cross road, in roadway) as well as what the pedestrian is doing at the time (e.g. working on a vehicle, pushing a motor vehicle, going to or from school). While this information is useful, it should not be assumed that only one of these options can apply in any given crash. For example, if a child is traveling to

school walking on a sidewalk, which option should the responding officer indicate on the crash report? Or, if a vehicle breaks down and the driver is out of the vehicle in the roadway examining their engine or mechanics, which option would apply?

Another example occurs when responding law enforcement is asked to identify the “first harmful event” that occurred prior to the crash. There are 69 options for the officer to choose from that range from circumstances that could occur (e.g. downhill runaway, crossed median/centerline, equipment failure) to objects involved in a collision (e.g. animal, parked motor vehicle, guardrail, etc). This also includes an option for a pedestrian. This category encompasses so many options that are again, not mutually exclusive, that it can be difficult to identify just one on the crash report. For example, if a dog ran across the road causing a vehicle to swerve across the centerline and hit a pedestrian walking along the shoulder, which option would apply? Technically, the “first” harmful event was the dog, however an officer could justify that since the vehicle did not hit the animal, perhaps the first harmful event was crossing the centerline or even hitting the pedestrian. In 72.8% of pedestrian crashes, the crash report lists “pedestrian” as the first harmful event contributing to the crash. Even when in a majority of cases the officer’s narrative clearly identifies another event occurring prior to the crash.

Obscure data options are also a problem on the crash form and in reporting. In 167 crashes involving a pedestrian (2.4%), the vehicle maneuver at time of crash was identified as “parked”. Does this refer to the car that hit the pedestrian, or did the pedestrian park their own car and was then hit standing outside the vehicle? If the officer does not provide a thorough narrative (discussed below) this can severely limit any analysis of the crash reports and data.

The biggest drawback for a number of categories on the crash form is the large number of un-informative categories (i.e. invalid, not provided, not applicable, other and unknown). One of these options was selected as the vehicle maneuver in 16.4% of pedestrian crashes. With 14 specific options to choose from (not including the 5 shown here), it is difficult to assume that the information was unavailable or was not discovered through the investigation in such a large sample of cases.

This leads to the second major cause for inaccuracy in the crash report data. Responding law enforcement are not appropriately trained to deal with investigating and reporting on crashes

involving pedestrians. A large majority of the errors and omissions can likely be attributed to the complicated process required to include pedestrian information in the current crash report form, and the inherent limitations in the options for each variable, as described above. If law enforcement representatives are not specifically trained in completing the crash form for a crash involving a pedestrian, there will likely be many errors or omissions due to their inexperience or unfamiliarity regarding how to do it correctly. Additionally, on 12% of crash reports analyzed for this research, the responding officer provided no diagram or narrative of the crash. This could be due to limited time on the officer's part, the expectation that they could return to the report and fill in details at a later time, or simply officer laziness. Discussions with the Utah Highway Safety Office and UDOT also revealed that many officers may be hesitant to put details of their investigation down in the narrative, because they fear that if errors are identified they could either face discipline or repercussions for any inaccuracies, or that individuals could be wrongly prosecuted even though under Utah law the narrative portion of the crash form is inadmissible in court. This may lead to a behavior pattern where the crash forms are intentionally left blank, leaving out important information from the scene of the crash.

5.2.2 Common Characteristics among Fatal Pedestrian Crashes

Fatal pedestrian crashes are unique and complex. However, there are a number of characteristics that are regularly present in fatal crashes. This analysis found that over 10% of fatal pedestrian crashes occurred during inclement weather with wet or icy roads. Statistical analyses also found that the weather differed significantly during fatal vs non-fatal pedestrian crashes. This is not surprising considering that a vehicle traveling on wet or icy roads would likely have reduced braking ability or may skid or hydroplane if they came upon a pedestrian unexpectedly. Also, drivers have a lower expectation of pedestrians when the weather is poor since fewer people walk or bike in bad weather. This makes it all the more important for drivers to reduce speeds and increase awareness during inclement weather.

Vehicle maneuvering at the time of the crash significantly differed between fatal and non-fatal pedestrian crashes. In 78% of fatal crashes the vehicle was traveling straight prior to the crash. This was significantly more common than when a vehicle was turning (left turns - 6.3%; right turns - 2.5%). This may not immediately seem intuitive since many would consider

turning more dangerous and more likely to result in a conflict between pedestrians and vehicles. However, a vehicle preparing to turn is likely either slowing or stopping prior to the turn. If they are then involved in a crash with a pedestrian while turning, the impact would occur at a lower speed which, as shown in the literature review, has a significantly lower likelihood of being fatal. As the analysis showed, crashes involving a right turning vehicle are 95% less likely to be fatal for this reason. Vehicles traveling straight are likely traveling at or above the posted speed. Crashes involving vehicles traveling straight would therefore result in more fatalities. Furthermore, the analysis found that vehicles involved in fatal pedestrian crashes were traveling significantly faster (relative to the posted speed limit) than vehicles involved in non-fatal crashes.

Drivers directly contributed to the cause of the fatal crash in a majority of cases. Distracted driving was a contributing factor in nearly 20% of fatal crashes. The most frequently cited distractions were: cell phones (texting or talking- 43%), adjusting the radio (14.2%), and the glare of the sun (14.2%). Driving under the influence (9.5%) and speeding (5%) also contributed to fatal crashes. Each of these factors has been previously identified for the danger that they pose to the driving public (Zero Fatalities, 2016). This data simply reinforces the point that distracted, aggressive, and impaired driving negatively impacts pedestrians as well.

5.2.3 Pedestrian Contributions to Fatal Crashes

Pedestrians often directly contributed to fatal crashes. The most common pedestrian actions noted in fatal pedestrian crashes include improper crossing of the roadway (21.5%), being improperly in the roadway (10%) and lack of visibility (8%). All of these behaviors violate existing Utah code and are citable offenses. Being in the roadway improperly increases the odds of a pedestrian fatality by nearly 70%.

The age of the pedestrian significantly differs in fatal vs non-fatal pedestrian crashes. Pedestrians killed in a crash are on average 14 years older than those who survive a crash. This may have several explanations. First, younger people may simply be more likely to survive a crash due to biological and physiological factors. Second, younger individuals may be more likely to obey traffic regulations, such a crossing at marked and signaled locations where fewer fatal crashes occur. Third, younger individuals may be less likely to participate in secondary hazardous behaviors such as drinking and drug use, which can contribute to delayed reaction

time and impaired decision making that may precede a fatal pedestrian crash. Because data is not collected on pedestrian impairment, it was not analyzed in the research.

5.2.4 The Impact of Timing

The data showed a cluster pattern of fatal pedestrian crashes occurring between 5:00pm and 7:00am during lower light/dark conditions. An analysis of light conditions found that only 25% of fatal crashes occurred during daylight. Moreover, 66.9% of fatal crashes occurred in the dark and 5.5% occurred at dawn or dusk. Not only is the lighting condition a contributing factor, but for crashes occurring later in the night or very early in the morning, driver or pedestrian fatigue may play a substantial role, which could increase reaction times and impair judgment. Also, drivers may have a lower expectation of pedestrians being present late at night or very early in the morning, which could reduce a driver's propensity to visually scan for pedestrians.

While the initial analysis found no significant difference between fatal and non-fatal crash distribution by day of the week, a subsequent more sophisticated analysis identified that the odds of a fatal crash occurring on the weekend were significantly higher than a weekday. There is also a significant difference in crash severity by time of year. Fatal pedestrian crashes occur more often in the early spring and late fall when the weather is changing and there are fewer pedestrians on the streets. Lower volumes lead to less visibility as drivers may not be conditioned to seeing pedestrians at these times of year and would be less likely to visually scan for non-motorized travelers along the roadway. There are significantly fewer fatal pedestrian crashes in the summer, with the exception of a spike in July, likely due to the large increase in pedestrian traffic and outdoor activities surrounding both national and state holidays.

5.2.5 Can Characteristics Predict a Fatality?

Results from several Logit models were able to significantly predict if a pedestrian crash would be fatal, based on crash characteristics. The odds of a fatal crashes occurring in daylight, or while a vehicle is turning right are significantly lower than at night or when a vehicle is traveling straight. The odds of a fatal crashes occurring in bad weather (sleet/hail), when the driver is speeding, on roadways with more lanes, or when a pedestrian is improperly in the road are significantly higher than standard conditions. Additionally, the older a pedestrian is, the

more likely the crash is to be fatal. Lastly, the odds of a fatal crash occurring in March, July, October, and December were higher than in September.

When the above data is coupled together, it paints a clearer picture of a typical fatal pedestrian crash. Fatal crashes are most likely to occur in the early spring or late fall in inclement weather or lower light conditions when visibility is already limited and the roadway is wet or icy. They likely involve a pedestrian who may be impaired and is improperly in the roadway. Fatal crashes also most likely involve an impaired or distracted driver that is speeding straight ahead. These factors become the perfect formula for a tragic deadly outcome.

5.3 Limitations and Challenges

Like most research, this analysis required the use of a sample of cases rather than the entire population. This led to the one major limitation of this study. Because of time and labor constraints, the project scope did not involve investigating and confirming/adjusting the crash report coding for all pedestrian crash reports (both fatal and non-fatal). The analysis in Section 4.2 identified some serious accuracy and validity issues within the sample of 119 crash reports that were reviewed in detail. Considering that up to 66% of crash reports included in this research contained at least one data error, recoding all pedestrian crash reports would have likely resulted in a more robust and more accurate dataset, which could have yielded different analysis results. Future research is warranted to examine the accuracy of a larger sample of crash reports, and should include both fatal and non-fatal crashes.

6.0 RECOMMENDATIONS AND IMPLEMENTATION

6.1 Recommendations

Three major recommendations have been identified based upon the analysis presented in the previous sections.

6.1.1 Evaluation of Current Crash Reporting Procedures

Analysis can only be as accurate as the data on which it is based. If the coding of the crash data is inaccurate, then any subsequent analysis will also be flawed. This will result in programming and decision making based on inaccurate invalid data.

The first major recommendation is to conduct a thorough evaluation and consideration of the current components of the crash report; particularly those categories relevant to crashes involving pedestrians. As demonstrated in Section 5, many of the categories and selection options are duplicative, not mutually exclusive and even vague. Additionally, many of the categories on the current crash form provide such a large number of options as to be convoluted and confusing to anyone tasked with completing the form. This evaluation should focus on streamlining and simplifying the process for responding officers and law enforcement, making completion more straight forward and less time consuming. It is also recommended that the officer narrative be identified as a necessary submission. This would require the responding/investigating officer to at minimum provide a summary of the events surrounding the crash before the system would allow the submission.

6.1.2 Provide Additional Law Enforcement Training

The second recommendation of this research is that additional training be provided for law enforcement agencies regarding how to accurately and appropriately complete a crash report form for an incident involving a pedestrian. As evidenced in the evaluation of crash reports conducted for this research, many responding officers are unfamiliar with how to appropriately complete the report, and may be unsure of which pertinent information to include. A training could provide several case studies or scenarios for officers, and the instructor could then walk

them through exactly how to complete the forms paying particular attention to which characteristics are most important. The training could also include instruction on how to write a brief but effective narrative describing the crash.

6.1.3 Addressing Driver and Pedestrian Travel Behavior

The third and final recommendation derived from this research focuses on addressing the behaviors that contribute to fatal crashes. Transportation practitioners commonly refer to the “3 E” model when seeking to address pedestrian safety concerns (Brookshire, et al, 2016). The primary “Es” most often refer to:

- **Engineering** (and related policy changes) —Changes to the roadway environment or operations (e.g., provision of sidewalks, bike facilities, traffic signals) that affect the movement of pedestrians, bicyclists, and other road users. The roadway design and changes to the roadway environment often reflect or result from the policies, plans, or design guidelines that are in place.
- **Education**—Efforts made to educate pedestrians, bicyclists, drivers, or other groups in order to raise awareness of a particular law, safety issue, or behavior and motivate a change in attitude or behavior that will have a positive effect on safety.
- **Enforcement** —Law enforcement agency efforts to promote compliance with laws, ordinances, and regulations (e.g., speed limits, failure to yield, use of crosswalks, use of bicycle facilities) related to pedestrian and bicycle safety.

While this research identified many characteristics that contribute to or are correlated with fatal pedestrian crashes, none of the major factors can be specifically addressed through engineering. For example, although we know that pedestrian crashes on roads with more lanes are more likely to be fatal, it is unlikely that UDOT will agree to make all state roads narrower or reduce the number of travel lanes. Particularly when these types of fatal crashes are not clustered in a specific geographic area where focused engineering treatments may actually make a difference. Likewise, there is little that can be done to create artificial daylight, or manipulate weather patterns and seasonality. That leaves education and enforcement.

There are a number of state and national programs already in operation that deal specifically with educating drivers and pedestrians on transportation safety. For example, the Zero Fatalities Program (2016) directly addresses distracted driving, impaired driving and aggressive driving (speeding). Likewise, the Heads Up Program focuses on reducing pedestrian and bicycle crashes by teaching motorists to look out for non-motorized travelers. This includes admonitions to pedestrians to be alert and be seen (remove headphones and wear lights/reflective gear), cross the road in marked crosswalks or at street corners, look both ways before crossing a roadway, and avoid walking in the road. These programs more than adequately address the characteristics identified by this research as significant contributors to fatal crashes. Additionally, the Utah Pedestrian Safety Action Plan addresses education specifically through a variety of avenues. It is therefore recommended that these programs continue as prescribed.

Lastly, enforcement can play a critical role in addressing the number of dangerous behaviors that contribute to fatal pedestrian crashes. Again, many potentially beneficial programs are already in place, and time will tell how effective they can be in changing driver/pedestrian behavior. It is recommended that an evaluation of existing program effectiveness be conducted annually to identify which programs are seeing results, and which may need to be amended to create more positive outcomes.

6.2 Implementation Plan

6.2.1 Evaluation of Current Crash Reporting Procedures

To adequately review and evaluate existing crash report procedures it is recommended that a task force or panel be developed consisting of representatives from UDOT the Utah Highway Safety Office, the State Legislature and law enforcement agencies, to review each component of the crash reporting system and forms. This task force will examine and evaluate each component and accompanying selection options, discuss the merits and justification for the current system, and identify any necessary changes. The Task Force will then provide recommendations to appropriate agencies or legislators in cases where state legislature approval is required. The Task Force will also follow-up to ensure implementation of all recommendations.

6.2.2 Provide Additional Law Enforcement Training

The Department of Public Safety's Highway Safety Office has a training system for law enforcement agencies in place. UDPS will work with UDOT to amend existing or create appropriate new training materials for a class focusing on pedestrian crash reporting. This training will be made available to all agencies statewide and will be promoted through the traditional channels.

6.2.3 Addressing Driver and Pedestrian Travel Behavior

A review of progress on existing state and national programs currently underway should be conducted annually by UDOT and the UDPS to ensure that all programs adequately address dangerous driver and pedestrian behaviors. At the conclusions of each review, adjustments should be made to ensure the highest safety return on investment. A mechanism and framework for this review is already outlined and established as a part of the Utah Pedestrian Safety Action Plan.

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